MFJ-1025 noise canceling signal enhancer notes

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1 Circuit

A copy of the schematic from the manual is shown in fig. 1. The MFJ-1026 is similar. It contains an auxiliary preamp, and an internal whip antenna that can be used as a noise antenna.

In receive mode, the MFJ-1025 takes the input from two antennas, main and auxiliary. At each antenna input there is a high pass filter with 5.6 μH shunt inductors and a 600 pF series capacitor. These are L3, L4, C8 on the main input and L5, L6, C16, on the the the the AUX input. Assuming this is a Butterworth filter, this corresponds to

$$\begin{aligned} f_{3dB} &= \frac{1}{2\pi\sqrt{2LC}} = 1.94 \text{ MHz} \\ Z &= \sqrt{\frac{L}{2C}} = 68 \text{ Ohms}\,. \end{aligned} \tag{1}$$

This analysis is confirmed by both filters being terminated with a 100 Ohm resistor in parallel with a 250 ohm potentiometer

$$Z = \frac{100 \cdot 250}{100 + 250} = 71 \text{ Ohms}\,. \tag{2}$$

The potentiometer taps adjust the input signals to the gates of J310 FET amplifiers. These are the front panel gain controls. Since the gates are high impedance, the potentiometer adjustment does not affect the input impedance.

The main antennas potentiometer drives one input of an FET differential amplifier.

The auxiliary antenna's potentiometer arm drives a J310 amplifier which drives the all pass phase-shift network. One leg of the bridge is two series 51 ohm resistors (R17 and R18). The other leg is a switched capacitor (C12 or C13) in series with a 1K ohm potentiometer (R16) with the tap and one side grounded. The capacitor is switched between 470 pF (C12) and 120 pF (C13) by the front panel low/high frequency switch. The bridge output is transformer coupled (unun configuration) to a high impedance J310 FET amplifier which in turn drives the second input of the differential amplifier either as a source follower or grounded source amplifier providing normal or inverted phase shifts.

The differential amplifier drives a 2N5189 emitter follower to the output.

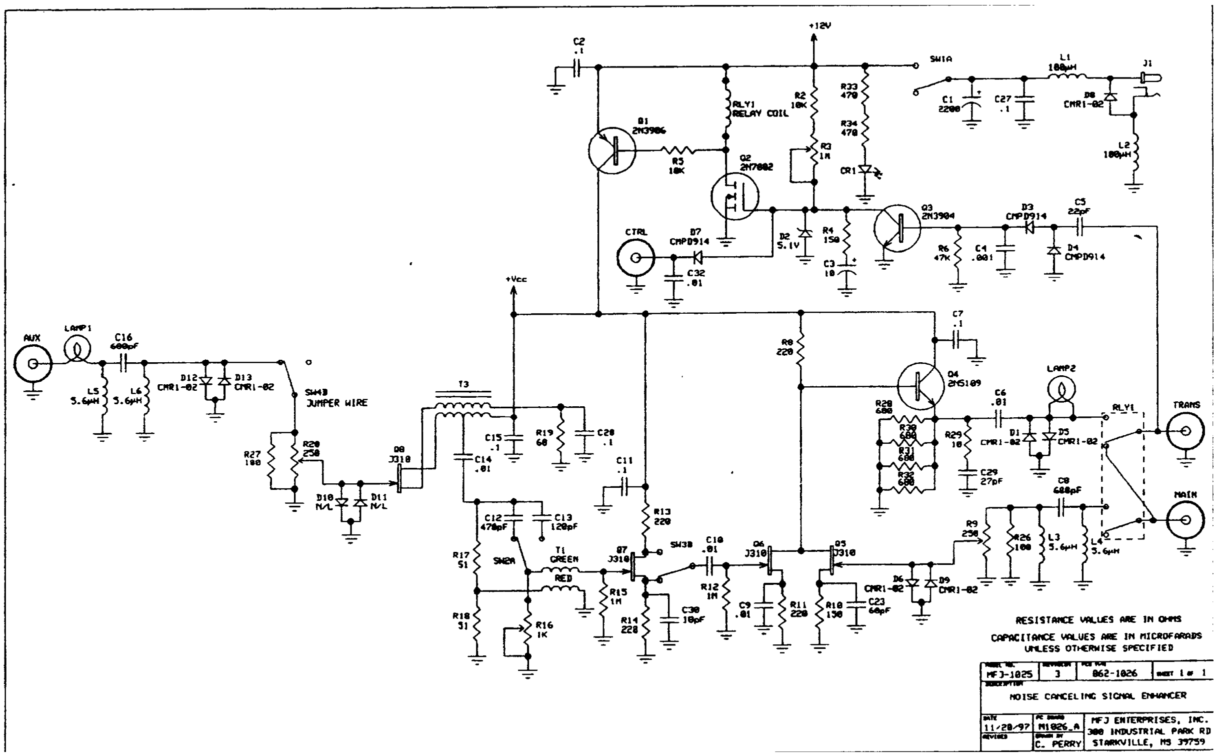

Figure 1: The MFJ-1025 schematic scanned from the manual. The full manual with schematic is available for download from www.mfjenterprises.com.

If the phase shift network is driven by a voltage V, the voltage divider consisting of the resistors R17 R18 will give a voltage of $\frac{V}{2}$. The voltage divider consisting of the capacitance C of C12 or C13 and potentiometer R16 of resistance R will give a voltage across R of $\frac{RV}{R+\frac{1}{j\omega C}}$. The FET is driven by the difference of these or

$$V_{\mathrm{aux}} = V\left[\frac{R}{R+\frac{1}{j\omega C}} - \frac{1}{2}\right] = -\frac{V}{2}\frac{1-j\omega RC}{1+j\omega RC} \tag{3}$$

The numerator is the complex conjugate of the denominator, so the output level is independent of the value of RC. The phase shift is twice the phase of the numerator or

$$\theta = -2\tan^{-1}(\omega RC) \tag{4}$$

With the inversions in the circuit, the phase difference in radians between the two inputs would be

$$\begin{aligned} \theta &= 2\tan^{-1}(\omega RC) - \pi \\ \theta_i &= 2\tan^{-1}(\omega RC)\,. \end{aligned} \tag{5}$$

The range of phase angles for 160 meters is then $-180° < \theta < -21°$, and $0° < \theta_i < 159°$. A range of about 42° is missing out of the full 360°. On 80 meters, this becomes $-180° < \theta < -11°$, and $0° < \theta_i < 169°$, and a range of about 22° is missing.

Swapping the antennas changes the sign of the relative phase shifts and will allow coverage of all phase shifts.

2 Measurements

I connected an N2PK vector network analyzer between one antenna input and the receiver output of the MFJ with the other antenna input terminated in 50 ohms, and recorded the gain and phase shift. I then repeated this for the other antenna input. One set of measurements was made for each setting of the phase control from 0 to 10, and for both normal and inverted. As expected the gain and phase of the main antenna circuit was independent of the phase control setting.

The phase shift between the two antenna inputs at 160m and 80m are shown in figs. 2 and 3, along with the predicted phase shift from Eq. 5.

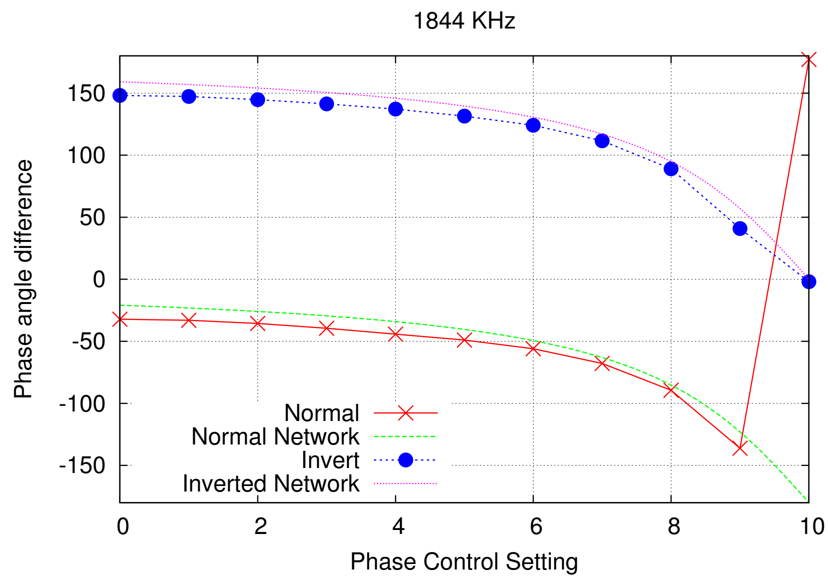

Figure 2: Measured phase shift and ideal network calculation at 1844 KHz. The jump for setting 10 is the phase changing to an angle slightly more negative than -180 degrees which is the same as an angle slightly less than 180.

The manual claims that the gain shift with full phase rotation is less than 2dB, and typically less than 1dB. In fig. 4, the measured gain shift (relative to setting 0) is shown for 160 and 80 meters.

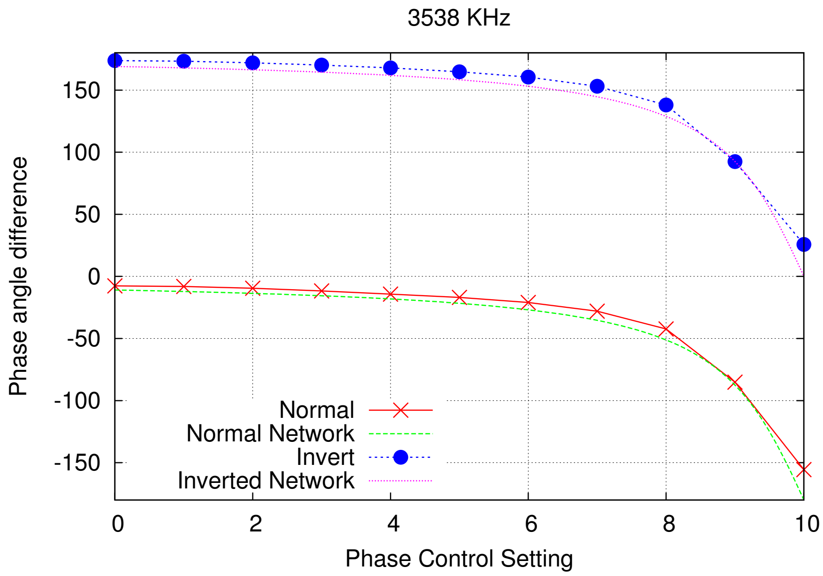

Figure 3: Measured phase shift and ideal network calculation at 3538 KHz.

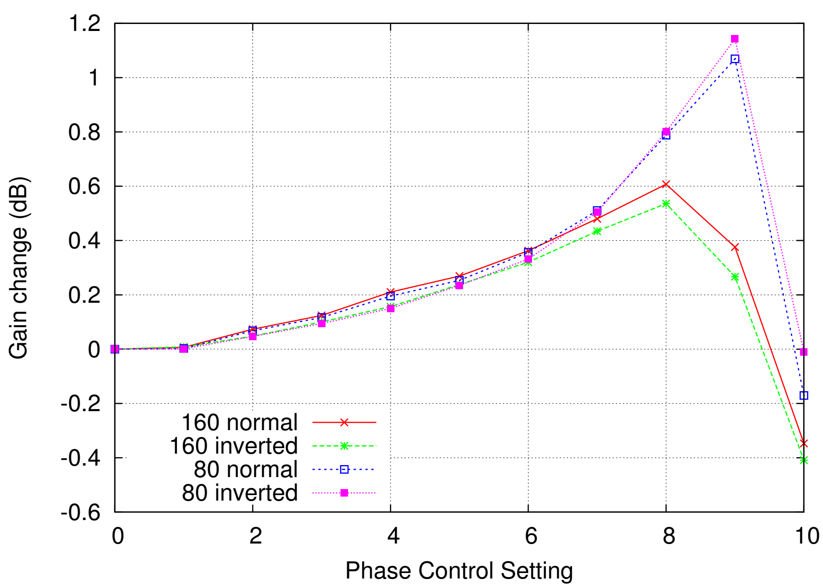

Figure 4: Measured gain variation relative to the phase control setting of zero for 160 and 80 meters.